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# **FUNGICIDAL CONTROL OF SMUT DISEASES OF CEREALS**

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B. von Schmeling<sup>1</sup> and Marshall Kulka<sup>2</sup>

The fungicide, 2,3-dihydro-5-carboxanilido-6-methyl-1,4-oxathiin, is a new chemical compound which is particularly useful as a seed treatment for control of various seed and soilborne diseases. It was jointly discovered at UNIROYAL Research Laboratories in Guelph, Ontario, and Bethany, Connecticut. In 1960 a relatively unexplored field of chemistry was encountered when 1,4-oxathiin derivatives were obtained as by-products during the synthesis of sulfur mustards (1). In 1962 other 1,4-oxathiin derivatives were synthesized and a general method for the preparation of 1,4-oxathiins was developed based on the method of Marshall and Stevenson (2). A year later 2,3-dihydro-5-carboxanilido-6-methyl-1,4-oxathiin was prepared by this method and found to act systemically against certain plant pathogenic fungi (3).

The method of preparation (4) consists of reaction of  $\alpha$ -chloro-acetoacetanilide with 2-mercaptoethanol under basic conditions to form  $\alpha$ -( $\beta$ -hydroxyethylmercapto)-acetoacetanilide and cyclization and dehydration of this intermediate or of its enol to 2,3-dihydro-5-carboxanilido-6-methyl-1,4-oxathiin (DCMO).

DCMO is a crystalline compound having two crystal structures with melting ranges of 91.5-92.5°C and 98.0-100°C. In solution these two crystal structures revert to one and biological tests have shown no difference in activity. The chemical is fairly water soluble (170 ppm) and quite soluble in such organic solvents as acetone (60%) and methanol (21%).

The high degree of specificity of the chemical against basidiomycete type fungi (5) includes the unique ability to control the barley and wheat loose smut fungus Ustilago nuda (Jens.) Kell. and SW, and U. tritici Jens., respectively (6,7).

DCMO appears to be readily absorbed by the plant tissue and translocated in the water-conducting vessels to the site of the pathogen. Its main translocation pattern, as shown in barley and wheat seed treatment experiments with radio-labeled material is in an upward direction. The residues in parts per million in the plant tissue are rapidly diluted and metabolized by plant growth. No detectable residues occurred in grain harvested from plants grown in the field from seed treated with the C<sup>14</sup>-labeled chemical. The method used was sensitive to 0.05 ppm. Indications are that DCMO loses its fungicidal effectiveness in soil or on seed within a period of three weeks. Colorimetric and GLC residue methods are being developed.

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In regard to toxicology, DCMO has an acute oral LD<sub>50</sub> for rats of 3,200 mg/kg and an acute dermal LD<sub>50</sub> for rabbits of >8,000 mg/kg. Sub-acute animal toxicity tests have been completed with favorable results and two-year feeding tests are in progress. They will be completed during the summer of 1968.

DCMO is available to growers through selected distributors for the 1968 growing season under approved experimental labels for seed treatment of barley, wheat, cotton, peanuts, and grain sorghum grown for planting seed purposes only. A petition for a full label for these crops will be submitted to the Food and Drug Administration in 1968 and if approval is obtained in time, commercialization with a certain allowed residue tolerance is expected to begin for the 1969 fall planting season.

DCMO is available in different formulations. The main seed treatment formulation is a wettable powder containing 75% active ingredients which is suitable for dry or slurry as well as ready-mix seed treatments. Other formulations include a 5 lb/gal liquid, a 10% active dust, and a 5% active granule mixture.

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# CONTROL OF LOOSE SMUT OF WHEAT AND BARLEY IN ARKANSAS WITH FUNGICIDES<sup>1</sup>

J. P. Jones and R. D. Barnett<sup>2</sup>

The systemic fungicide DCMO is effective in controlling several smut diseases. Tests of DCMO were made at Fayetteville, Arkansas, during 1966-67, using seed of 'Knox' wheat and 'Larker' barley<sup>3</sup> naturally infected with loose smut, caused by *Ustilago tritici* (Pers.) Rostr., and *Ustilago nuda* (Jens.) Rostr., respectively. The wettable powder was applied to the seed as a slurry at rates of 2, 4, and 8 ounces per 100 pounds of seed, both with and without an additional treatment of an organic mercury fungicide, Pan. 15, at 1/2 oz per bushel. The treated seed, along with two control lots of seed, non-treated and treated with Pan. 15 alone, were planted in drill strips 7 x 130 ft at the Main Experiment Station. Wheat was planted in the fall of 1966 and barley in the spring of 1967 and at heading time the plots were examined for smutted plants.

Good control of loose smut of wheat was obtained with the 4- and 8-oz DCMO treatments, both with and without the Pan. 15 overtreatment, but control was only fair with the 2-oz treatment (Table 1). Excellent control of barley loose smut was secured with all DCMO concentrations. The overtreatments with the organic mercury fungicide did not interfere with the efficiency of DCMO in controlling smut. The two fungicide treatments apparently are compatible when applied together in this manner. In addition, no phytotoxicity was observed from any treatments. DCMO shows promise as a control for these two smut diseases.

Table 1. Effect of DCMO seed treatment on loose smut of wheat and barley.

Treatment	Knox wheat	Larker barley
	Number of smutted plants <sup>a</sup>	
No treatment	111	500
DCMO, 2 oz <sup>b</sup>	24	14
DCMO, 4 oz	8	1
DCMO, 8 oz	5	1
Pan. 15, 0/2 oz <sup>c</sup>	210	500
DCMO, 2 oz; Pan. 15, 1/2 oz	49	2
DCMO, 4 oz; Pan. 15, 1/2 oz	8	0
DCMO, 8 oz; Pan. 15, 1/2 oz	2	1

<sup>a</sup>In drill strips containing approximately 2,600 plants.

<sup>b</sup>Per 100 pounds of seed. <sup>c</sup>Per bushel of seed.

<sup>1</sup>Published with approval of the Director of the Arkansas Agricultural Experiment Station, Fayetteville, Arkansas.

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<sup>3</sup>Barley seed obtained courtesy of Arnold W. Walz, Uniroyal, Inc. Bethany, Connecticut.

## CHEMICAL CONTROL OF LOOSE SMUT IN BARLEY

Vernyl D. Pederson<sup>1</sup>

Seed treatment tests for barley loose smut control were conducted at three locations in South Dakota in 1966 and 1967.<sup>2</sup> The tests in 1966 included DCMO at dosages of 2 and 4 oz/100 lb seed and PMAA at a dosage of 1 oz/100 lb seed. Tests in 1967 were expanded to include DCMO, G-696, and several additional seed treatment fungicides (Table 1). Each of the chemicals were applied as seed treatments alone and DCMO and G-696 at each dosage was combined with each of the other chemicals to determine their compatibility. Seed lots of 'Larker' barley containing 24 and 28% smut-infected kernels were used for the tests in 1966 and 1967, respectively.

A randomized plot design with 4 replications was used for all experiments. Each plot consisted of four 12-foot rows. After heading, healthy and smutted heads were counted in 10 linear feet per plot. Yields were determined.

Virtually 100% control of loose smut was obtained with both systemic chemicals whether used alone or combined with other chemicals. There was no significant difference in smut control among dosages or between systemic chemicals. There were no significant differences in total heads among treatments, and there was no indication of phytotoxicity. Percent increase in yield from seed treated with systemic chemicals was approximately equal to percent loose smut control.

Table 1. Seed treatment chemicals and dosages used for barley loose smut control in South Dakota, 1967.

Chemical	oz/100 lb seed
DCMO	2
DCMO	4
DCMO	8
G-696	1/2
G-696	1
G-696	2
Thiram 75%	2
Thiram 75%	4
Captan 60%	4
Cer. MDB	4
Pan. PX	4
PMAA	1

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# CHEMICAL CONTROL OF WHEAT AND BARLEY LOOSE SMUT

Richard L. Kiesling<sup>1</sup>

## Abstract

Systemic organic, oxathiin and thiazole fungicides controlled loose smut of barley and wheat at 2 ounces or less per bushel. The oxathiin fungicide was effective in combination with other seed treatment compounds.

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Field and greenhouse trials of oxathiin and thiazole systemic seed treatment chemicals for the control of loose smut of wheat and barley were conducted in 1966 and 1967 at Fargo, North Dakota. Barley seed lots containing a high percentage of loose smut, as determined by the embryo test, were cleaned without removing small seeds. The cleaned grain was then weighed into kilogram samples and mixed with the correct amount of chemical in large flasks. Treatments requiring large amounts of dust were pelleted to the seed. Treated seed was planted in 100 to 150 foot rows at one-foot spacings. Four random samples of 250 heads each were counted per row. Counts were made when over 95% of the heads of the tillers had emerged. Spring wheat seed lots containing small amounts of loose smut were also treated as above, except that the entire row was counted for smutted heads.

Control of loose smut in both spring wheat and barley was obtained in both test years (Tables 1-3). Check rows in 1966 developed an average of 32.4% smutted heads, and the check rows in the 1967 trials showed an average of 25.5% smut. Using the oxathiin compound, DCMO, treatments of 2 ounces or more per bushel gave economic control of the disease (Tables 1,2). In the 1966 trials complete control of loose smut of barley was obtained at the 4 ounces per bushel rate of application. Several combinations of oxathiin and other seed treatment compounds were tried in the 1967 trials with no apparent decrease in effectiveness of loose smut control (Table 2). All of these treatments completely eliminated the loose smut in the spring wheat trials (Table 3).

A thiazole was tested in the 1967 trials (Tables 2,3). It appeared to be effective on barley at a one ounce per bushel application, and in wheat a 3/4 ounce per bushel application resulted in complete control.

Seedling stand counts and yields were also taken on the 1967 trials. Seedling stands in barley and wheat treated with either oxathiin or thiazole alone were not significantly different from the untreated checks.

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Table 1. The control of loose smut in 'Larker' barley with oxathiin systemic fungicides, 1966.

Treatment	Rate oz/bu	No. smutted heads per 1000
DCMO, Dust	1	26
DCMO, Dust	2	4
DCMO, Dust	4	0
DCMO, Pelleted	2	2
DCMO, Pelleted	4	1
DCMO, Pelleted	6	0
DCMO, Pelleted	8	0
Check	None	324

Table 2. The effect of systemic seed treatment fungicide on percent loose smut of Larker spring barley, 1967.

Treatment	Rate oz/bu	Loose smut percent <sup>a</sup>
DCMO, Dust	3	0.3
DCMO, Dust	2	0.3
DCMO, Pelleted	2	0.0
DCMO, Liquid (5 lb)	3	0.0
DCMO + Pan. 15	3+3/4	0.0
DCMO + Thiram	6	0.0
DCMO + Thiram	4	0.3
DCMO + PCNB + Terr.	3+3	0.1
DCMO + PCNB S-X	3+3	0.2
G-696	2	0.5
G-696	1	0.1
G-696	3/4	1.1
Check	0	25.5

<sup>a</sup>Smut per 1000 heads.

No evidence was found from the field data or from greenhouse data (Table 4) to indicate that infected seed was differentially killed by these fungicides. Significant yield increases were obtained in the barley trials in 1967, but the increases were of the magnitude expected on the basis of loose smut control. No significant increases in wheat yields were obtained by loose smut control because of the low smut content.

Table 3. The effect of systemic seed treatment fungicide on the percent loose smut of 'Justin' spring wheat, 1967.

Treatment	Rate oz/bu	Loose smut	
		per 130	ft row
DCMO, Dust	3	0	
DCMO, Dust	2	0	
DCMO, Pelleted	2	0	
DCMO, Liquid (5 lb)	3	0	
DCMO + Pan. 15	3+3/4	0	
DCMO + Thiram	6	0	
DCMO + Thiram	4	0	
DCMO + PCNB + Terr.	3+3	0	
DCMO + PCNB S-X	3+3	0	
G-696	2	0	
G-696	1	0	
G-696	3/4	0	
Check	0	41	

Table 4. The effect of oxathiin systemic fungicide seed treatment on loose smut and seedling emergence of Larker barley in greenhouse trials.

Treatment	Rate oz/bu	No. of smutted heads or missing seedlings per 30 plants	
		Infected	Missing
DCMO, Dust	1/4	5	0
DCMO, Dust	1/2	6	6
DCMO, Dust	3/4	3	4
DCMO, Dust	1	3	4
DCMO, Dust	2	2	2
DCMO, Dust	4	0	0
DCMO, Pelleted	2	0	0
DCMO, Pelleted	4	0	2
DCMO, Pelleted	6	0	1
Check	None	4	2

# SEED TREATMENT TRIAL - 1967

H. A. H. Wallace<sup>1</sup>

Two formulations of DCMO, each applied at two dosages, were tested in 1967 against common bunt of wheat (Tilletia foetida (Wallr.) Liro), covered smut of oats (Ustilago kollerii Wille), covered smut of barley (Ustilago hordei (Pers.) Lagerh.), and seed rots of flax and wheat caused by a complex of soilborne and seedborne microorganisms.

One gram of appropriate smut spores was dusted on 200 grams of clean 'Red Bobs' wheat, naturally smutted 'Vanguard' oats, and naturally smutted 'Plush' barley. 'Manitou' wheat of low vitality and 'Marine' flax were used for emergence tests.

Each chemical was applied at the dosage indicated (Table 1) to 200 grams of the infested seed and shaken well in a sealed one-quart glass jar. Two days later 200 seeds from each treatment were packaged in envelopes, placed in polyethylene bags, and stored at about 15°C until seeded (about one month).

Table 1. Percent smutted heads and plant emergence from seed treated with DCMO.

Original test number	Chemical	Formu- lation	Dosage oz/bu	Smutty heads %			Emergence %	
				wheat	oats	barley	flax	wheat
1	Untreated check		-	17.77	7.13	6.80	75.2	21.4
21	DCMO	Dust	2.0	0.08	0.04	0.08	74.4	19.3
22	DCMO	Dust	4.0	0.13	0.00	0.25	72.9	17.6
23	DCMO	Liquid	1.25	0.00	0.04	0.13	71.9	17.2
24	DCMO	Liquid	2.50	0.00	0.00	0.00	74.6	19.7
53	Untreated check		-	21.61	8.08	7.08	73.9	19.9
	L.S.D.			9.25	1.85	1.75	8.5	5.0

All crops were sown at Brandon, Morden, and Winnipeg in the Province of Manitoba, Canada. The plots, which were rows 12 feet long and 9 inches apart, were replicated 4 times at each station. The percentage of smutty heads, based on counts of 200 heads per row, and the percentage emergence based on 200 seeds per row, are given in Table 1.

At both dosages the dust and liquid formulations each gave practically complete control of bunt, covered smuts of oats, and barley. Treatment did not increase the emergence of flax or wheat, but no phytotoxicity was apparent at the dosages used.

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# EFFECT OF CHEMICAL TREATMENTS ON THE CONTROL OF LOOSE SMUT IN BARLEY

T. T. Hebert<sup>1</sup>

## Abstract

Attempts to control loose smut in barley by soaking seed in fungicidal solutions in organic solvents and by applying fungicides as slurries containing dimethyl sulfoxide were unsuccessful. The systemic fungicide DCMO was effective in controlling loose smut.

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In 1963 Millborrow (1) reported that seed of several plant species could be soaked in certain organic solvents without reduction in seed germination. When barley seeds were soaked in a solution of DDT in acetone, dried, and then planted, the DDT was absorbed by the seed and translocated to the seedling leaves. These results prompted an attempt to control loose smut (*Ustilago nuda* (Jens.) K. & S.) in barley by soaking seed in fungicidal solutions in organic solvents and by slurry treatments containing dimethyl sulfoxide (DMSO). In 1965 the systemic fungicide 2,3-dihydro-5-carboxanilido-6-methyl-1,4-oxathiin (DCMO) became available and was also tested for loose smut control. This note reports the results of these tests.

Preliminary tests indicated that barley seed could be soaked for 1 hr in acetone, petroleum ether (boiling point 65-110°C) and ethanol without reduction in germination. Methanol reduced germination considerably. Fungicides were then dissolved or suspended in organic solvents and 100 g of barley seed was soaked in 200 ml of the fungicidal solutions for 1 hr. The seed was then drained, dried, and planted a month later in four 16-foot rows in a randomized block design. The number of smutted heads produced are recorded in Table 1.

These treatments failed to control the smut. Other treatments which also failed to control smut were: (1) soaking seeds in 0.5% solutions of captan, dichlone, or zineb in acetone for 6 hr, (2) soaking seed in each of these three fungicidal solutions for 1 hr, draining, and then storing in a closed container for 48 hr before allowing them to dry, and (3) soaking seeds for 1 hr in 1% Pan. 15 in acetone.

In another test an attempt was made to control loose smut by slurry treatments with fungicides suspended or dissolved in aqueous solutions of 2, 10, and 50 percent DMSO. The slurry was applied at the rate of 2 ml of slurry per 100 g of seed. The seed was packaged and planted as in the previous test. The results of this test (Table 2) show that these treatments were ineffective in controlling smut.

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Table 1. Smutted heads produced by barley after soaking for 1 hr in solutions or suspensions of fungicides in organic solvents.

Treatment	% w/v of Fungicide	Solvents		
		Petroleum		
		Acetone	ether	Ethanol
		(number smutted heads)		
Solvent only		57	47	38
maneb	0.8	68	33	43
dichlone 50%	0.5	37	52	34
dodine	0.65	86	42	56
DCNA	0.5	65	75	54
folpet	0.5	83	51	42
captan	0.5	52	34	-
Agri.	1.0	48	43	47

Table 2. Smutted heads in barley after treatment of seed with fungicidal slurries containing DMSO.

Treatment	Fungicide per 100 lbs. seed	Percent DMSO in slurry		
		2	10	50
		(number smutted heads)		
Check (water)		20	30	23
ferbam 68%	6 oz	32	21	16
captan	4 oz	23	21	26
thiram	4 oz	22	28	19
chloranil	8 oz	35	27	22

In the 1965-66 and 1966-67 seasons DCMO was used in conventional slurry treatments made up in water. The barley available had only a low percentage of infected seed. One seed lot was used in 1965-66 and three different seed lots were used in 1966-67. Treated seed were planted in four replications of 16-foot rows using 25 grams of seed per plot. The total number of smutted heads for each treatment is shown in Table 3.

DCMO appears to be effective in controlling loose smut in barley. One smutted plant was found in the rows from treated seed in 1965-66. This may have resulted from the failure of some seeds to become thoroughly coated with the fungicide. In 1966-67 two rates were tried using 2 pints of slurry per 100 lb of seed in an effort to get more complete seed coverage. Again a smutted plant was found in the rows from seed treated with the higher rate of slurry. Although DCMO failed to eliminate smut completely in these tests, the degree of control appears to be sufficiently high to make this

Table 3. Control of loose smut in barley by seed treatment with DCMO.

Treatment	Rate per 100		Number smutted heads			
	lbs seed		1965-66	1966-67		
	DCMO	Water		Lot 1	Lot 2	Lot 3
Untreated	0	0	—	29	22	8
Water	0	1 pt	37	14	16	8
DCMO	2 oz	1 pt	0	0	3	1
DCMO	4 oz	1 pt	0	1	0	0
DCMO	8 oz	1 pt	3	—	—	—
DCMO	4 oz	2 pt	—	0	2	—
DCMO	8 oz	2 pt	—	0	0	—

a very useful product in the control of loose smut of barley. No adverse effects on seed germination or plant growth were noted in barley treated with this fungicide.

#### Literature Cited

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#### A SYSTEMIC OXATHIIN FUNGICIDE TO CONTROL LOOSE SMUTS, COVERING SMUTS, SEED ROTS, AND SEEDLING BLIGHTS OF WHEAT, BARLEY, OATS, AND SORGHUM<sup>1</sup>

Earl D. Hansing<sup>2</sup>

#### Abstract

Experiments conducted in the field from 1965 to 1967 demonstrated that DCMO applied as a seed treatment effectively controlled loose smut (Ustilago tritici) of wheat and brown loose smut (U. nuda) of barley, and was comparable to recommended fungicides in controlling bunt (Tilletia foetida) of wheat, loose (U. avenae) and covered (U. kolleri) smuts of oats, covered kernel smut (Sphacelotheca sorghi) of sorghum, and seed rots and seedling blights of wheat and sorghum.

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## LOOSE SMUT (USTILAGO TRITICI) OF WHEAT

One hundred cc lots of 4 varieties of winter wheat were treated with the systemic fungicides DCMOD, DCMO, and the mercurial fungicide Pan. 15 (Table 1). Two days later (fall 1965) each treatment for each variety was planted in the field in 5 replicated 16-foot rows. Complete control of loose smut was obtained with DCMO at 4 oz/cwt and at 2 oz/cwt for all varieties except 'Clarkan'. No control was obtained with the mercurial fungicide.

Table 1. Control of loose smut of winter wheat and brown loose smut of spring barley.

Fungicide	Form <sup>a</sup>	Rate oz/ cwt	Wheat					Barley
			Bison	Clarkan	Kiowa	RedChief	RedChief	Larker
			% smutted spikes					
No treatment	-	-	13	19	14	32	18	26
DCMOD	PS	2	6	2	2	6	3	-
DCMOD	PS	4	2	3	1	4	1	-
DCMO	PS	1	-	-	-	-	-	9
DCMO	PS	2	0	0.2	0	0	0	1
DCMO	PS	4	0	0	0	0	0	0
Pan. 15	L	1	14	17	16	35	18	27

<sup>a</sup>PS = powder to slurry, L = liquid.

For the 1966-1967 year seed for several acres of foundation 'Bison', 'Lancer', and 'Shawnee' wheats were treated with DCMO at 4 oz/cwt, 2 oz/cwt, and 4 oz/cwt, respectively. Complete, 95%, and 99% control, respectively, of loose smut was obtained.

## BROWN LOOSE SMUT (USTILAGO NUDA) OF BARLEY

Five hundred cc lots of 'Larker' spring barley were treated with DCMO (Table 1). Pan. 15 was included as a control. One day later each treatment was planted in the field in 5 replicated 16-foot rows. Effective (95%) control was obtained with DCMO at 2 oz/cwt and complete control at 4 oz/cwt. No control was obtained with the mercurial fungicide.

During 1966 and 1967 farmers' samples of susceptible varieties of barley were obtained from the Kansas State Seed Laboratory, treated and planted in our field nursery. Highly effective control (complete control in most cases) was obtained when the seed was treated with DCMO at 4 oz/cwt.

## CONTROL OF SEED ROTS, SEEDLING BLIGHTS, AND BUNT OF WHEAT

Five hundred cc seed lots of 'Ottawa' and 'Scout' winter wheat were treated with DCMOD, DCMO, and 4 fungicide controls (Table 2). Six days later each treatment for each variety was field planted, randomized in 5 replications with 200 seeds in each 16-foot row. Emergence counts were made when the plants were in the 2-leaf stage. DCMO increased seedling stand 12% and yield of wheat 1 bu/a.

Table 2. Control of seed rots, seedling blights, and bunt of winter wheat.

Fungicide	Form <sup>a</sup>	Rate oz/bu	Mean emergence <sup>b</sup>	Mean yield <sup>b</sup> bu/a	Days planted after treating			
					1965		1966	
					2	4	1	4
No treatment	--	--	% 56	24.4	% bunted spikes <sup>c</sup>			
Fungicide controls					82	86	67	61
Captan	PS	1	67	28.5	6	8	11	16
Thiram	PS	1	68	28.1	3	8	7	8
Cer. L	L	0.5	66	27.6	T <sup>d</sup>	0	2	1
Pan. 15	L	0.75	64	27.7	0	0	T	0
Systemic fungicides								
DCMOD	PS	1.33	59	--	35	53	38	55
DCMOD	PS	2.67	58	--	23	37	24	32
DCMO	PS	1.33	62	25.6	3	8	10	7
DCMO	PS	2.67	63	25.4	1	1	1	2

<sup>a</sup>PS = powder to slurry, L = liquid.

<sup>b</sup>Varieties: Ottawa and Scout, emergence fall 1965, yield summer 1966.

<sup>c</sup>June 1966 and June 1967, respectively.

<sup>d</sup>T = trace = 0.1 to 0.5%.

'RedChief' winter wheat seed was inoculated artificially at the rate of 0.5% spores (Tilletia foetida) by volume. Two and 4 days (1965) and 1 and 4 days (1966) after treating, each treatment was planted in the field in 3 replicated 10-foot rows. DCMO at 2.67 oz/bu was comparable to the methylmercurial fungicides for control of bunt (98% to 99% control, respectively).

## CONTROL OF LOOSE AND COVERED SMUTS OF OATS

'Kanota' oat seed was inoculated artificially, by the partial vacuum method, with a suspension of chlamydospores (Ustilago avenae and U. kolleri). After the seed was dried, 500 cc lots were treated with DCMOD, DCMO, and 3 fungicide controls (Table 3). One and 3 days (1966) and 2 and 6 days (1967)

Table 3. Control of loose and covered smuts of Kanota oats.

Fungicide	Form <sup>a</sup>	Rate oz/bu	Days planted after treating			
			1966		1967	
			1	3	2	6
			% smutted panicles			
No treatment			41	27	64	72
<u>Fungicide controls</u>						
Cer. L	L	0.5	1	T <sup>b</sup>	3	3
Pan. 15	L	0.75	T	T	2	3
Chloranil	P	2	29	21	34	38
<u>Systemic fungicides</u>						
DCMOD	PS	1.33	2	1	4	3
DCMOD	PS	2.67	0	T	2	2
DCMO	PS	0.67	—	—	1	1
DCMO	PS	1.33	0	0	0	0
DCMO	PS	2.67	0	0	0	0

<sup>a</sup>L = liquid, PS = powder to slurry, P = powder.

<sup>b</sup>T = trace = 0.1 to 0.5%.

after treating, each lot was planted in the field in 3 replicated 10-foot rows. DCMOD and DCMO were comparable to the methyl mercurial fungicides for control of oat smut (97%, 99.7%, and 97% control, respectively).

#### CONTROL OF SEED ROTS, SEEDLING BLIGHTS, AND COVERED KERNEL SMUT OF SORGHUM

Five hundred cc seed lots of RS608 and RS610 (1966) and RS610 and RS625 (1967) sorghum hybrids were treated with DCMOD, DCMO, and 4 fungicide controls (Table 4). Four days (1966) and 3 days (1967) later each treatment for each hybrid was field planted, randomized in 5 replications with 200 seeds in each 16-foot row. Emergence counts were made when the plants were in the 2-leaf stage. DCMO at 1.33 oz/bu and 2.67 oz/bu in 1966 and at 2.67 oz/bu in 1967 was comparable to captan and thiram, and more effective than the mercurial fungicides, for control of seed rots and seedling blights. No control was obtained with DCMOD.

'Pink kafir' sorghum seed was inoculated artificially at the rate of 0.5% spores (Sphacelotheca sorghi) by volume. One and 4 days after treating each sample was planted in the field in 2 replicated 40-foot rows. DCMOD and DCMO were comparable to the fungicide controls for control of covered kernel smut (Table 4).

Table 4. Control of seed rots, seedling blights, and covered kernel smut of sorghum.

Fungicide	Form <sup>a</sup>	Rate oz/bu	Mean emergence <sup>b</sup>		Days planted after treating			
					1966		1967	
			1966	1967	1	4	1	4
No treatment	---	---	% 46	% 31	% smutted panicles			
					26	29	18	24
<u>Fungicide controls</u>								
Captan	PS	1	61	63	0	0	0	0
Thiram	PS	1	60	57	0	0	0	0
Cer. L	L	0.5	55	--	0	0	-	-
Pan. 15	L	0.75	54	51	0	0	0	0
<u>Systemic fungicides</u>								
DCMOD	PS	1.33	48	31	1	0	1	T <sup>c</sup>
DCMOD	PS	2.67	48	32	0	0	0	0
DCMO	PS	0.67	--	38	-	-	T	T
DCMO	PS	1.33	64	52	0	0	0	0
DCMO	PS	2.67	64	63	0	0	0	0

<sup>a</sup>PS = powder to slurry, L = liquid.

<sup>b</sup>Hybrids RS608 and RS610 in 1966, hybrids RS610 and RS625 in 1967.

<sup>c</sup>T = trace = 0.1 to 0.5%.

# CONTROL OF BARLEY LOOSE SMUT IN WISCONSIN IN 1966 AND 1967<sup>1</sup>

R. W. Ahrens, D. C. Army, G. L. Worf and L. J. Wrage<sup>2</sup>

Loose smut, caused by Ustilago nuda (Jens.) Rostr., is endemic on the barley crop in Wisconsin. Although physical treatments of seed have been developed that are effective in controlling the disease, they are rather cumbersome and exacting and have not been widely accepted. An effective, simple chemical treatment would be more acceptable to growers, and would allow the disease incidence to be substantially reduced in the state.

<sup>1</sup>Published with the approval of the Director, Wisconsin Agricultural Experiment Station.

<sup>2</sup>Respectively, Extension Specialist, Department of Plant Pathology; Professor, Department of Plant Pathology; Associate Professor and Extension Specialist, Department of Plant Pathology; and Extension Specialist, Department of Agronomy, University of Wisconsin, Madison.

In 1966 Army compared two promising candidate chemicals in a field plot with a series of anaerobic water soak treatments and an organic mercury fungicide on a seed lot of 'Traill' barley which was heavily infected. Counts were made of the numbers of smutted heads which developed. The results follow (Table 1):

Table 1. Control of Ustilago nuda of barley with certain chemical and physical treatments.

Treatment	% germination of seed	No. smutted heads/ 20 ft row <sup>a</sup>
DCMO, 2.7 oz/bu		0
DCMO, 5.3 oz/bu		0
DCMOD, 2.7 oz/bu		5.0
DCMOD, 5.3 oz/bu		3.5
Pan. 15, 0.75 oz/bu		139.5
Anaerobic water soak, 60 hr	94	7.5
Anaerobic water soak, 72 hr	92	3.5
Anaerobic water soak, 84 hr	92	2.0
Anaerobic water soak, 96 hr	79	0
Anaerobic water sqak, 108 hr	83	6.0
Anaerobic water soak, 120 hr	75	5.5
No treatment	95	110.5

<sup>a</sup>Average of 2 replications

Because of the excellent response obtained with DCMO in this trial and those reported from other research stations, a number of plots were established over the state in 1967 to determine the performance of the chemical under varying conditions. Twelve plots of the variety 'Dickson', which had 2% infection by embryo test, were treated with 4 oz DCMO/bu. In addition, 4 plots of the variety 'Larker' were established, with 27.9% infected seed provided by Mr. Otto Wenger of Uniroyal, Inc. Since the number of infected heads of Dickson barley was quite low, no detailed counts were made of this

Table 2. Control of barley loose smut of the variety Larker at 4 locations in 1967.

Location (County)	% infected heads	
	DCMO, 4 oz/bu	Not treated
Columbia	0	14.1
Oconto	1.0	18.5
Racine	4.2	16.3
Rock	1.3	21.2

variety. At one of the 12 locations the treatment apparently delayed maturity of the crop a few days. No other deleterious effects were noted. Counts made in the Larker variety plots at Columbia, Oconto, Racine, and Rock Counties yielded the data shown in Table 2.

It is interesting to note that the treatment was least effective in the Racine County plot. Why this result occurred there is not understood.

Control was considered good in all locations, however, and the effectiveness of DCMO for controlling loose smut of barley is encouraging.

### EFFICACY OF OXATHIIN FUNGICIDES FOR CONTROL OF LOOSE SMUT IN BARLEY<sup>1</sup>

R. H. Littrell and D. D. Morey<sup>2</sup>

In 1967 approximately 9,000 acres of barley (Hordeum vulgare L.) were grown in Georgia. This represents approximately 3% of the total acreage in the state planted to small grains. Plant breeders are continuing their efforts to develop improved barley varieties for the southeast with combined resistance to leaf rust, powdery mildew, loose smut and other diseases. Breeding for resistance to loose smut caused by Ustilago nuda (Jens.) Rostr. has impeded the progress in the development of varieties. High-yielding varieties and promising breeding lines have been discarded because of loose smut susceptibility.

Promising results have been obtained from the oxathiin derivatives, DCMO and DCMOD, in the control of loose smut of barley by seed treatment (2). Edington and Reinbergs (1) reported that in greenhouse tests DCMO gave complete control of loose smut in 'York' barley when known infected seed were treated at a rate of 4 oz/100 lbs of seed. The purpose of this study was to test the effectiveness of DCMO and DCMOD for control of loose smut in Georgia and to determine if control was sufficient to eliminate breeding for resistance.

### MATERIALS AND METHODS

'Colonial' barley seed infected with U. nuda were treated separately with DCMO and DCMOD and a combination of the two materials. Rates of 4, 8, and 16 oz/100 lbs of seed were employed using wettable powder formulations. In com-

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<sup>1</sup>University of Georgia College of Agriculture Experiment Stations, Coastal Plain Experiment Station, Tifton. Journal Series No. 237.

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bined treatments the fungicides were mixed 1:1 to give same total dosages. Seed were treated by tumbling the seed and chemical in large glass jars on October 7, 1966, four days before they were planted. Land preparation practices and fertilizer applications were based on standard practices for the Coastal Plain area. One tone of dolomitic limestone and 600 lbs of 5-10-15 fertilizer were applied by broadcasting before land was turned. Seed (10 g, approximately 287 seed) were planted in 10-ft rows and each treatment was replicated 4 times in a randomized complete block design. The number of smutted heads were counted on April 11, 1967.

## RESULTS AND DISCUSSION

The results are given in Table 1. DCMO gave almost complete control at the 4-oz level with one smutted head observed. Complete control was obtained at 8 and 16 oz with no observable phytotoxicity. DCMOD did not completely control loose smut even at the 16-oz rate, although some reduction was obtained. It appears that 4 oz of DCMO is necessary for eradication, since smut was observed in the 2-oz level in combination with DCMOD. Mixing the two fungicides together did not reduce the efficacy of DCMO. It appears to us that breeders will not have to be too concerned about breeding for loose smut resistance based on the information from this test and reports from others.

Table 1. Number of smutted heads of Colonial barley from seed treated with DCMO and DCMOD.<sup>1</sup>

Fungidices	Rate (oz/100 lbs)	No. smutted heads/10 ft row					
		R-1	R-2	R-3	R-4	Total	Mean
DCMO	4	0	0	0	1	1	0.25
DCMO	8	0	0	0	0	0	0.0
DCMO	16	0	0	0	0	0	0.0
DCMOD	4	11	14	4	4	33	8.2
DCMOD	8	10	4	7	10	31	7.8
DCMOD	16	4	2	2	4	12	3.0
DCMO + DCMOD	2+2	3	3	6	2	14	3.5
DCMO + DCMOD	4+4	0	0	0	0	0	0.0
DCMO + DCMOD	8+8	0	0	0	0	0	0.0
Control		23	5	17	8	53	13.3

<sup>1</sup>Seed planted October 11, 1966; readings taken April 11, 1967.

## Literature Cited

1. EDINGTON, L. V. and E. REINBERGS. 1966. Control of loose smut in barley with systemic fungicides. Canadian J. Plant Sci. 46: 336.
2. von SCHMELING, B. and M. KULKA. 1966. Systemic fungicidal activity of 1,4-oxathiin derivatives. Science 152: 659-660.

# CHEMICAL CONTROL OF LOOSE SMUT IN BARLEY IN MINNESOTA

E. E. Banttari<sup>1</sup>

## MATERIALS AND METHODS

In one season of testing (1967) two lots of 'Larker' (CI 10648) with 17 and 24% and one lot of 'Dickson' (CI 10968) with 6% of seed infected with Ustilago nuda (Jens.) Rostr. were treated with DCMO at the rate of 4 oz/100 lbs of seed and planted at Crookston, Morris, and St. Paul. Rod rows of treated and non-treated seeds were replicated three times at each location.

## RESULTS

Counts of seedling emergence were made at St. Paul; counts of smutted and non-smutted heads were made at Crookston and St. Paul and the plots were harvested and yields calculated for the three locations. These data are shown in Table 1.

Table 1. Seedling emergence, smut infection and yield of barley which was non-treated or treated with DCMO.

Treatment	Emergence <sup>a</sup>	Smut counts <sup>b</sup>			Yield <sup>c</sup> bu/a
		Infected	Healthy	% infected	
<u>17% Larker</u>					
DCMO	324	0.5	259	< 1	54
Non-treated	242	46.0	224	17	48
<u>24% Larker</u>					
DCMO	356	0.5	230	< 1	66
Non-treated	262	71.0	225	24	53
<u>6% Dickson</u>					
DCMO	240	0.1	228	< 1	65
Non-treated	262	15.0	232	6	63

<sup>a</sup>Each figure is the average emergence/rod row in 3 replications at St. Paul.

<sup>b</sup>Each figure is an average count of infected or healthy culms in 8 ft of row in each of 3 replicates at Crookston and St. Paul.

<sup>c</sup>Calculated from yields of rod rows of 3 replications of Larker at 3 locations and 3 replications of Dickson at 2 locations.

<sup>1</sup>Assistant Professor, Department of Plant Pathology, University of Minnesota, St. Paul, Minnesota 55101. Paper No. 6436, Scientific Journal Series, Minnesota Agricultural Experiment Station.

The fungicide at this rate of application gave almost 100% control of loose smut in all three lots of seed at all three locations. The seed treatment improved seedling emergence in the two lots of Larker and increased yields 3, 11, and 20% in treated over that in non-treated controls in Dickson, and the 17 and 24% loose smut Larker lots, respectively. The seedling emergence of treated Dickson was not consistent with the results obtained with the Larker lots. This may have been due to sampling error in the counts.

## CHEMOTHERAPY OF LOOSE SMUT OF BARLEY IN CANADA

L. V. Edgington<sup>1</sup>

Research on therapy of loose smut of barley at the University of Guelph has been conducted by Drs. E. Reinbergs and L. V. Edgington, and Mr. Gordon Monroe, a graduate student. Most of our research has been reported previously (1,2). Part of this work has been in cooperation with Drs. D. R. Metcalfe and V. M. Bendelow at Winnipeg, Manitoba (2). The results may be summarized as follows:

1. Seed treatment with DCMO at 4 oz/100 lb seed consistently reduced smut from 49% of heads in untreated 'Parkland' and 16% in 'York' to 0% in field plots at both Guelph, Ontario and in Manitoba.
2. DCMO was effective in controlling smut when combined with methylmercurydicycandiamide, captan, and thiram, indicating that these fungicides were compatible. Combination treatments may prove necessary as DCMO is not toxic to non-basidiomycetes such as Fusarium and Bipolaris.
3. The therapeutic effect of DCMO applied to the seed does not persist until bloom. Plants grown from treated seed were just as susceptible to floret infection as plants grown from untreated seed.
4. Malting quality of harvested barley grown from treated seed was equivalent to that produced from untreated seed.
5. Heading of barley was delayed by 1 to 2 days in field plots grown from seed treated with DCMO.
6. Seed can be treated any time during the year prior to planting. Barley seed treated in 1966 was still viable and produced plants free from smut when planted one year later.
7. A liquid formulation of DCMO was found as effective as the wettable powder formulation but cannot be used on all kinds of seeds. The solvent used for the liquid formulation was found to be phytotoxic to onion seed.

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<sup>1</sup>Associate Professor, Department of Botany, University of Guelph, Guelph, Ontario, Canada.

8. DCMOD was not as effective as DCMO for controlling smut when applied as a seed treatment, but 5% DCMOD granules applied at 5 lb active/acre in the seed furrow gave complete control.
9. G-696, a thiazole compound related to DCMO, also gave complete control of loose smut when applied as a liquid formulation at 2 oz active/100 lbs seed.

#### Literature Cited

1. EDGINGTON, L. V. and E. REINBERGS. 1966. Control of loose smut in barley with systemic fungicides. Can. J. Plant Sci. 46: 336.
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#### RESULTS OBTAINED WITH A SYSTEMIC OXATHIIN FUNGICIDE IN FRANCE

G. Richard and J. Cognet<sup>1</sup>

A wettable powder DCMO was tested in France in 1967. The trials were conducted by the Soc. La Quinoleine (Lauzun and Ballancourt), by the Pharmacological Laboratory of the National Institute of Agricultural Research (Versailles) and by the Society for the Study of and Commerce in Malt Barleys (Maule).

The trials were conducted with a lot of barley seed infected with Ustilago nuda and with a lot of oat seed infected with Ustilago avenae.

#### USTILAGO NUDA

The four trials were made with one seed lot of spring barley variety 'Ceres.' The trials were arranged on the principle of blocks of multiple replications. The trial at Lauzun had ten replicated plots 2 x 1 m seeded with 28 g per plot. The trials at Versailles and Maule had four replicated plots of 1 x 1 m seeded with 20 g per plot and of 10 x 1.6 m seeded with 185 g per plot, respectively. The treatment was by coating dry seeds. The experimental rates were within the range which had been shown to be efficacious in 1966 in the United States.

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<sup>1</sup>Technical Manager and Assistant Technical Manager, respectively, Services de Recherches Agronomiques, La Quinoleine S.A., 43 Rue de Liege, Paris 8, France.

The results given in Table 1 show that:

1. At all experimental rates, including the lowest (150 g to 100 kg seed, or about 1.5 oz to the bu), DCMO gave a total control of U. nuda.
2. No apparent phytotoxicity was observed in any of the trials.
3. The 1000-grain weight, done only in the trials at Lauzun and Ballancourt, showed no unfavorable effects.

#### USTILAGO AVENAE

A trial was made at Lauzun with the oats variety 'Noire de Moyencourt.' The trial had ten replicated plots 2 x 1 m seeded with 15 g per plot. The results are given in Table 2. The results show that DCMO gave complete control of U. avenae at all the experimental rates.

In conclusion, DCMO applied at the rate of 150 g/100 kg of seed was shown to be 100% effective on the two pathogens, nuda loose smut of barley and smut of oats.

Table 1. Results on Ustilago nuda.

Fungicide/ 100 kg seed	Total No. spikes	No. smutted spikes	% smut	1000-seed weights
<u>Lauzun</u>				
Check	7,535	984	13.05	49.4 g
DCMO 150 g	7,442	0	0	50.0 g
DCMO 200 g	7,759	0	0	-
DCMO 250 g	7,408	0	0	50.7 g
<u>Ballancourt</u>				
Check	8,611	781	9.08	41.2 g
DCMO 150 g	7,934	0	0	43.0 g
DCMO 200 g	--	0	0	-
DCMO 250 g	7,969	0	0	41.8 g
<u>Versailles<sup>a</sup></u>				
Check	205	27	13.1	
DCMO 150 g	220	0	0	
DCMO 225 g	168	0	0	
DCMO 300 g	163	0	0	
<u>Maule</u>				
Check	5,418	374	6.9	
DCMO 250 g	4,972	0	0	
DCMO 350 g	5,550	0	0	

<sup>a</sup>In the Versailles trial, count was taken on the plants, not on the spikes.

Tests will be made in 1968 for the purpose of:

1. Confirming results obtained in 1967.
2. Determining the minimum effective rates of application.
3. Testing the activity of DCMO on wheat smut (Ustilago tritici) and on corn smut (Ustilago maydis).
4. Determining the efficacy of DCMO used alone or in association with other fungicides, on other pathogenic fungi.

Table 2. Results on Ustilago avenae.

Fungicide/ 100 kg seed		Total No. panicles	No. smutted panicles	% smutted panicles
Mercury (1.5% hg)	200 g	3,514	42	1.19
maneb 48%	200 g	3,446	19	0.55
DCMO	150 g	3,458	0	0
DCMO	200 g	3,145	0	0
DCMO	250 g	3,180	0	0
Check		3,127	121	3.86

PRELIMINARY OBSERVATIONS ON THE TREATMENT OF WHEAT AND BARLEY WITH  
A FUNGICIDE TO CONTROL LOOSE SMUT IN ENGLAND

R. C. F. Macer<sup>1</sup>

The incidence of wheat loose smut (Ustilago tritici) and barley loose smut (U. nuda) has increased in the United Kingdom in the past decade. A new physiologic race (C4), virulent on the previously smut-resistant winter wheat variety 'Cappelle-Desprez', has become widespread and of major importance. The new "open-flowering" barley varieties 'Impala', 'Maris Otter', and 'Zephyr' are more susceptible to loose smut than the "closed-flowering" varieties 'Proctor' and 'Maythorpe' which they replaced. The established smut control treatments and seed multiplication procedures have been inadequate to prevent the increases of the diseases.

The tests with DCMO were designed to collect data upon phytotoxic effects, and the effectiveness against loose smut. All seed was from the 1966 harvest. DCMO was applied as a dust or as a slurry, to 500 g batches of

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<sup>1</sup>Director of Scientific Development, Rothwell Plant Breeders, Rothwell, Lincolnshire, England.

seed (except the hand-inoculated barley) using laboratory glassware. In the hand-inoculated barley (inoculated by hypodermic needle at anthesis) the seed was mixed with wheat for treatment and subsequently separated by hand. In the glasshouse experiments the plants were grown to the second leaf stage (for viability) or to the ear emergence (for smut assessment). In the field experiment the seed were hand-sown in 4-ft rows.

No decline in germination or evidence of abnormalities in the coleoptile, prophyll, or second leaf were found on 7 wheat or 6 barley varieties treated with 3 or 5 oz/cwt of DCMO. Very significant reductions in smutted plants of Cappelle-Desprez wheat and Zephyr barley were obtained with seed treatments of 3 and 5 oz/cwt of DCMO (Table 1). Complete elimination of loose smut was achieved only in one case. DCMO reduced the percent infection of plants from seed inoculated by the hypodermic needle from 87.3 to 0.7% (Table 2). In a field test, seed treatment with DCMO reduced the incidence of loose smut from 1.55 to 0.19% in Impala barley (Table 3).

Table 1. Effect of DCMO treatment on wheat and barley seed naturally infected by U. tritici and U. nuda (glasshouse test).

Variety	Treatment	No. plants	% infection
<u>Wheat</u>			
Cappelle	untreated	400	4.4
Cappelle	3 oz powder	400	0.3
Cappelle	5 oz powder	400	0.0
<u>Barley</u>			
Zephyr	untreated	500	6.8
Zephyr	3 oz powder	500	0.2
Zephyr	5 oz powder	500	0.2

Table 2. Effect of DCMO treatment on barley seed infected by U. nuda following inoculation at anthesis (glasshouse test).

Variety	Treatment	No. plants	% infection
Impala	untreated	300	87.3
Impala	5 oz powder	300	0.7

Observations during the 1966-67 growing season have given indications that DCMO when applied to wheat or barley seed (as a dust or as a slurry), significantly reduces the incidence of loose smut at heading without impairing seed germination. The experimental results were carried out on a "laboratory" scale and in a single growing season only and must, therefore, be treated with reserve. Also, the glasshouse experiments were carried out at a temperature considerably above the natural ambient.

Table 3. Effect of DCMO treatment on barley seed naturally infected by U. nuda (field test).

Variety	Treatment	No. plants	% infection
Impala	Control	3802	1.55
Impala	4 oz powder	3652	0.19

#### CONTROL OF BARLEY LOOSE SMUT BY AN 1,4-OXATHIIN DERIVATIVE

H. E. Reed, A. Y. Chambers, and C. O. Qualset<sup>1</sup>

#### Summary

The systemic fungicide DCMO applied as a slurry seed treatment to an experimental line of winter barley (Tenn. 59-15), gave complete control of loose smut (Ustilago nuda) at 2 and 5 oz/bu. No adverse effects were obtained on seedling stand and plant growth using this compound at the 2 oz rate/bu. Another fungicide, TH-174F, applied at 5 oz/bu was phytotoxic and failed to control loose smut.

#### INTRODUCTION

Most of the cultivated barleys are relatively susceptible to loose smut caused by the fungus, Ustilago nuda (Jens.) Rostr. The disease is widespread, occurring in most barley-growing areas, but damage is greatest in those regions where humid, cool weather occurs during the barley heading period. In Tennessee, loose smut is usually present to some degree in every field of barley with the percentage of infected heads per field usually ranging from a trace to 5%. However, under certain conditions the percentage of infected heads is much higher and greater losses in grain yields are sustained, since losses in grain yields have been estimated to be equivalent to the percentage of loose smut present. Control of the disease by the hot water and anaerobic methods of seed treatment have proven to be impractical for general use and seldom are practiced. As a result barley growers accept the disease as one to live with and substantial losses in grain yields have occurred over the years. Recently von Schmeling and Kulka (4) announced that a new class of oxathiin systemic fungicides showed promise of controlling smuts and rusts. Edgington et al. (2) found a selective toxicity of these fungicides to basidiomycetes and confirmed (1) that these chemicals applied

<sup>1</sup>Associate and Assistant Professors of Plant Pathology, respectively, Department of Agricultural Biology, University of Tennessee, Knoxville, and formerly Assistant Professor of Agronomy, University of Tennessee, Knoxville (now in the Agronomy Department, University of California, Davis).

as seed treatments prevented loose smut of barley. Hansing (3) found that DCMO was effective as a seed treatment in controlling loose smut (Ustilago tritici) of winter wheat.

The present studies were undertaken to determine the effectiveness and practicality of a systemic fungicide, DCMO, for controlling loose smut of winter barley when applied as a seed treatment. Another chemical, TH-174F, also thought to have systemic properties, was likewise evaluated.

## MATERIALS AND METHODS

Two different tests were made; one at the West Tennessee Experiment Station, Jackson, and the other at Knoxville, Tennessee.

In the Jackson experiment, DCMO and TH-174-F were evaluated for control of loose smut, seedling stand, and grain yield. An organic mercurial treatment, Pan. 15, and the standard hot water treatment were also included for comparison of seedling stand and grain yield. An experimental line of barley (Tenn. 59-15), harvested from two different heavily loose-smut-infected plots was used. DCMO and TH-174-F were applied as slurry seed treatments, while Pan. 15 was applied directly to the seed in concentrated form. Four replications of the four seed treatments and the untreated check were seeded at the rate of 2 bushels per acre on October 6, 1966, in 2-row plots 20 feet long. Seedling stand counts were made 4 weeks after planting, and the percentage of smutted heads was calculated using 6 feet of each of the 2 rows of each plot of the 4 replicates. The plots were harvested in June using a combine.

In the test at Knoxville, DCMO was the only chemical tested. Four replications of the DCMO treatment and the untreated check were seeded at a rate of 2 bushels per acre on December 1, 1966, in 4-row plots 10 feet long. The number of healthy and smutted plants was recorded on May 23, 1967.

## RESULTS AND DISCUSSION

In the Jackson experiment (Table 1) DCMO and hot water treatments gave complete control of loose smut and resulted in grain yields of 15% more than the untreated checks. However, this difference was not significant ( $P > .05$ ). No loose smut control was effected by Pan. 15 or TH-174-F. The hot water and TH-174-F treatments decreased the seedling stand and significantly more seedlings were present in the Pan. 15 treated plots than in plots of these two treatments. DCMO had no adverse or beneficial effects on stand establishment.

In the Knoxville experiment (Table 2), DCMO at the 5 ounce rate per bushel likewise gave complete control of loose smut without any adverse effects on plant growth, even though the rate of application was higher than in the Jackson experiment.

Table 1. Effect of seed treatments on seedling stand, the incidence of loose smut, and grain yield of Tenn. 5915 barley at Jackson.

Treatment	Seedling stand	%	Grain yield	
	(Av. no. plants per ft of row)	smutted heads	bu/a	% of check
Check	38.2	25.0	47.0	100
Pan. 15 (3/4 oz/bu)	43.1	25.3	46.4	99
Hot water	24.8	0	54.0	115
DCMO (2 oz/bu)	37.7	0	54.5	116
TH-174-F (5 oz/bu)	29.6	27.7	46.6	99
L.S.D. (.05)	5.9		N.S.	
C.V.	11.1%		16.6%	

Table 2. Effects of treatment of Tenn. 59-15 barley seed on control of loose smut of barley at Knoxville.

Treatment	Total no. plants	No. smutted plants	% smutted plants
DCMO (5 oz/bu)	219	0	0
Untreated check	179	27	15.1

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# EFFECTIVENESS OF FUNGICIDES IN CONTROLLING BARLEY LOOSE SMUT<sup>1</sup>

D. M. Kline<sup>2</sup>

I treated barley variety Florida 102 with several fungicides. The fungicides were applied to 1-lb seed lots at the following rates per bushel: Thiram, Cer. M, and DCMO at 1.5, 0.5, and 3.5 ounces, respectively, dissolved or suspended in 10 ml of water, and Chloroneb, 4.0 ounces in 10 ml of a 50-50 water-methanol solution. The slurry was pipetted into a 1/2-gallon jar and distributed over the inner jar surface; the seeds were added; and the jar was closed and agitated vigorously for 2 minutes. Seeds of the control were treated similarly with 10 ml of water. The seeds were thoroughly dried, packaged, and planted within 2 weeks. Each test consisted of 8 replicate plots of paired 8-foot rows in a randomized block design. The tests were planted in the fall of 1966 at Raleigh, North Carolina, and through the cooperation of D. D. Morey at the Georgia Coastal Plain Experiment Station, and D. T. Sechler at the North Florida Experiment Station. The smutted heads in 12 feet of row in each plot were counted in April 1967. The total number of smutted heads in the 8 replicate plots of the control and the 4 treatments are summarized in Table 1.

Table 1. Number of smutted heads from barley seeds treated with various fungicides.

Fungicide	Number of smutted heads			
	Raleigh, N. C.	Tifton, Ga.	Quincy, Fla.	Total
Water	41	36	27	104
Thiram	32	28	36	96
Cer. M	15	18	8	51
Chloroneb, 65%	37	34	40	111
DCMO	0	0	0	0

The number of smutted heads from seed treated with either Thiram or Chloroneb was approximately the same as in the control. No smutted heads were observed from seed treated with DCMO. The number of smutted heads from seed treated with Cer. M was approximately one-half the number observed in the control. The data demonstrate that DCMO is effective in eliminating loose smut from barley seed.

<sup>1</sup>Cooperative investigations of Crops Research Division, Agricultural Research Service, United States Department of Agriculture, and Department of Plant Pathology, North Carolina State University, Raleigh, North Carolina.

<sup>2</sup>Research Plant Pathologist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, North Carolina State University, Raleigh, North Carolina.

# EFFECT OF TWO SYSTEMIC FUNGICIDES ON CONTROL OF LOOSE SMUT IN WHEAT<sup>1</sup>

R. A. Kilpatrick and O. G. Merkle<sup>2</sup>

Loose smut (Ustilago tritici (Pers.) Rostr.) is a serious disease of 'Quanah' wheat (Triticum aestivum L. em Thell.) in Central Texas. The disease has reduced the acreages of this and other varieties. The anaerobic and hot water methods of treating seeds have not proven successful in eliminating the causal organism. With the development and use of systemic fungicides for controlling loose smut, a susceptible variety such as Quanah could regain its value for commercial and breeding purposes.

Consequently, an experiment was designed for testing the systemic fungicides. Chemicals were prepared by Uniroyal, Inc. These consisted of: (1) a 1:1 mixture of 2,3-dihydro-5-carboxanilido-6-methyl-1,4-oxathiin (DCMO) and 2,3-dihydro-5-carboxanilido-6-methyl-1,4-oxathiin-4,4-dioxide (DCMOD); (2) a 1:1 mixture of DCMO and DCMOD, plus 50% activated charcoal; and (3) DCMOD alone. Seeds were treated with: No. 1 at the rate of 5 oz/bu, and No. 2 at 10 oz/bu. DCMOD at 10 g/gal was sprayed on plants at 6-week intervals 3 times during the growing season to see if spray applications would control loose smut.

Seeds were treated two days prior to planting on October 24, 1966, in four 10-ft rows, replicated three times. Non-treated seeds served as controls. Notes on number of smutted and healthy spikes were taken at time of heading.

Excellent control of loose smut was obtained by treating seeds (Table 1). Although combination treatments provided better than 99% control, the use of the 50% activated charcoal appeared to be slightly less effective than the 1:1 mixture alone. Spraying plants with DCMOD was ineffective for controlling the disease. Although preliminary, the data for one year's test offers encouragement for eliminating smut from infected lines for breeding and commercial purposes.

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<sup>1</sup>Cooperative investigations of Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture and Departments of Plant Sciences and Soil and Crop Sciences, Texas A&M University, College Station, Texas. Agricultural Experiment Station Technical article 7244.

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Table 1. Effect of treating Quanah wheat seeds with two fungicides for control of loose smut.

Treatment	Number of spikes		
	Healthy	Smutted	Percent
Non-treated	5,274 <sup>a</sup>	860	14.0
DCMO + DCMOD (1:1) 5 oz/bu	4,968	1	0.02
DCMO + DCMOD (1:1) plus 50% activated charcoal - 10 oz/bu	6,213	39	0.62
DCMOD spray - 10 g/gal; 3 applications	4,287	555	11.5

<sup>a</sup>Total number of spikes in three replications.

### CONTROL OF USTILAGO NUDA WITH A 1,4-OXATHIIN FUNGICIDE<sup>1</sup>

J. G. Moseman<sup>2</sup>

Barley loose smut, caused by Ustilago nuda (Jens.) Rostr., is a serious disease of winter barley in Eastern United States. The disease can be controlled with hot water or anaerobic treatments of infected seed. However, the seed germination may be reduced, or the control of smut may not be complete unless treatments are carefully controlled.

I conducted the test to determine if the fungus, U. nuda, could be eliminated by treating infected barley seed with the 1,4-oxathiin fungicide DCMO.

von Schmeling and Kulka (11) reported in 1966 that DCMO completely controlled loose smut (U. nuda) in barley. Edgington, Walton, and Miller (2), and Richard and Cognet (10) showed that DCMO effectively inhibited spore germination of several basidiomycetes, but was not effective against some phycomycetes, ascomycetes, or fungi imperfecti. Several investigators (1, 3, 8, 9, 10) have reported that they obtained complete control of loose smut of barley or loose smut of wheat (U. tritici) by treating infected seed with DCMO. Kiesling (6) obtained complete control of loose smut of wheat, but a few spikes (less than .5%) were infected with loose smut of barley when infected seed were treated with DCMO. Kuiper (7), in studies in Australia, obtained about 50% control of loose smut of wheat and barley, but obtained complete control of bunt of wheat (Tilletia foetida) and (T. caries), flag smut of wheat (Urocystis tritici), and covered smut of oats (Ustilago kolleri).

<sup>1</sup>Contribution of Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture.

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Kuiper suggested that DCMO was not effective because of the rapid plant growth and irrigation. However, he obtained only a 35% reduction in smutted plants when the treated seed were planted in the glasshouse. Richard and Cognet (10) obtained complete control of loose smut of oats (Ustilago avenae) by treating infected seed with DCMO. Some investigators (1, 9) have found DCMOD reduced loose smut of barley, but did not completely eliminate the fungus from infected seed. Hansing (3) reported that treating seed with DCMO almost completely controlled bunt of wheat. Hardison (4, 5) found that DCMO reduced flag smut (Urocystis agropyri) in Kentucky bluegrass, and stripe smut (U. striiformis) in several grasses, but that DCMOD was more effective in controlling those smut fungi.

The fungicide DCMO is compatible with organic mercury fungicides. DCMO was as effective in controlling loose smut of wheat or barley when used alone as when used with organic fungicides (1, 6). The addition of the mercury fungicides did not increase the yields significantly.

No phytotoxic effects were observed in barley or wheat plants from seed treated with DCMO by several investigators (3, 6, 9). However, Kiesling (6) reported a slight reduction in yield associated with the treatment of wheat and barley seed with DCMO. Reinbergs et al. (9) mentioned that some phytotoxic effects were evident on barley at the higher dosages of DCMO.

Reinbergs et al. (9) determined the effect of treatment of seed with DCMO on the malting quality of the harvested seed. The treatment did not affect barley nitrogen, soluble nitrogen, malt extract, or diastatic power of the seed.

Richard and Cognet (10) studied the toxicological properties of DCMO. They report the following results: (1) Acute oral toxicity on albino rats, D.L. 50:3,200 mg/kg; (2) acute dermal toxicity on adult rabbits, D.L. 50: more than 8,000 mg/kg; and (3) chronic toxicity on albino rats: a daily ingestion of 200 ppm for 90 days had not permitted microscopic observations or any observable changes to the naked eye.

D. A. Reid furnished the seed of Beltsville barley selection 63-1404, from the cross of Atlas 54 x<sup>4</sup> Colonial 2, used in this test. The seed was harvested from the Beltsville nursery in 1964, and was naturally infected with the loose smut fungus occurring in that nursery.

The test was conducted in the following manner: The seed and fungicide were weighed and placed in a fruit jar. A few drops of water were added before shaking the jar. The seeds were dried for 24 hours on a greenhouse bench and planted after 2 days. Two replications with three 12-foot rows per replication were planted in October 1966. A row of Harrison barley planted between each treatment prevented seed and plant mixtures and aided in harvesting. Individual smutted and healthy heads were counted in each row.

No infected heads were observed on plants from seed treated with 2, 4, or 8 ounces of DCMO per 100 lbs of seed, whereas 17.6% of the heads were infected from non-treated seed (Table 1). The average seed yield from treated plots was 40% more than that from non-treated plots.

Table 1. Barley loose smut control and yield increase from seed treatments with DCMO (Field - Beltsville 1966-67).

Treatment oz/cwt	Number of heads		Heads infected %	Grams of seed	
	Infected	Healthy		Total	% of check
None	383	1890	17.6	1108	100
2	0	2448	0	1538	139
4	0	2367	0	1516	137
8	0	2336	0	1586	143

The method of fungicidal application was simple and effective. The fungus in the seed was completely controlled by all rates of application. No phytotoxic effects were observed.

Breeding of wheat and barley varieties resistant to loose smut fungi should be continued even though the loose smut fungi in infected seed can be eliminated by DCMO. Not all commercially grown wheat and barley seed will be treated with DCMO. Plants from seed treated with DCMO may become infected with spores of smut fungi from adjacent fields. Loose smut can increase from less than 1 percent to several percent in seed of susceptible varieties in one year in the field. Also, wheat and barley varieties, having good agronomic characteristics and quality, are available that are immune or highly resistant to the loose smut fungi. By combining treatment of seed with DCMO and growing resistant varieties, spore populations should decrease and loose smut of wheat and barley could become a minor disease.

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DESIGNATION USED, CHEMICAL NAME, SOURCE, AND TRADEMARK NAME OF EACH FUNGICIDE  
MENTIONED IN THIS COMPILATION

Designation used in this compilation	Chemical name	Source	Trademark name
Agri.	15% Streptomycin sulfate + 1.5% Terramycin	Chas. Pfizer & Co., Inc.	Agrimycin
captan	N-((Trichloromethyl)thio)- 4-cyclohexene-1,2-dicarbox- imide		
Cer. L	2.89% Methylmercury 2,3- dihydroxypropylmercaptide and 0.62% Methylmercuric acetate	E. I. duPont de Nemours & Co.	Ceresan L
Cer. M	7.7% N-(Ethylmercuri)-p- toluenesulfonanilide	E. I. duPont de Nemours & Co.	Ceresan M
Cer. MDB	1.93% N-(Ethylmercuri)-p- toluenesulfonanilide	E. I. duPont de Nemours & Co.	Ceresan MDB
chloranil	Tetrachloro-p-benzoquinone		
Chloroneb	1,4-Dichloro-2,5-dimethoxy- benzene		
DCMO	75% 2,3-Dihydro-5-carbox- anilido-6-methyl-1,4- oxathiin	Uniroyal, Inc.	Vitavax
DCMOD	75% 2,3-Dihydro-5-carbox- anilido-6-methyl-1,4- oxathiin-4,4-dioxide	Uniroyal, Inc.	Plantvax
DCNA	75% 2,6-Dichloro-4-nitro- aniline	The Upjohn Co.	Botran

Designation used in this compilation	Chemical name	Source	Trademark name
dichlone	2,3-Dichloro-1,4-naphtho-quinone		
dodine	N-Dodecylguanidine acetate		
ferbam	Ferric dimethyldithiocarbamate		
folpet	N-((Trichloromethyl)thio)phthalimide		
G-696	75% 2,4-Dimethyl-5-carbox-anilido thiazole	Uniroyal, Inc.	
maneb	Manganous ethylenebis (dithiocarbamate)		
PMAA	7% Phenylmercuric ammonium acetate	Gustafson Mfg. Co.	Mist-o-matic
Pan. 15	2.2% Methylmercury dicyanodiamide	Morton Chemical Co.	Panogen 15
Pan. PX	.9% methylmercury dicyanodiamide	Morton Chemical Co.	Panogen PX
PCNB S-X	10% Pentachloronitrobenzene + 5% 5-Ethoxy-3-(Trichloromethyl)-1,2,4-thiadiazole	Olin Mathieson Chemical Co.	Terraclor Super X

Designation used in this compilation	Chemical name	Source	Trademark name
PCNB + Terr.	22.7% Pentachloronitro- benzene + 11.3% 5- Ethoxy-3-(Trichloro- methyl)-1,2,4-thiadiazole	Olin Mathieson Chemical Co.	Terracoat
TH-174-F	1-Phenyl-3-thiosemi- carbazine	Thompson-Hayward Chemical Co.	
thiram	Bis(dimethylthiocarbamoyl) disulfide		
Zineb	Zinc ethylene bis(dithio- carbamate)		